PRECISION

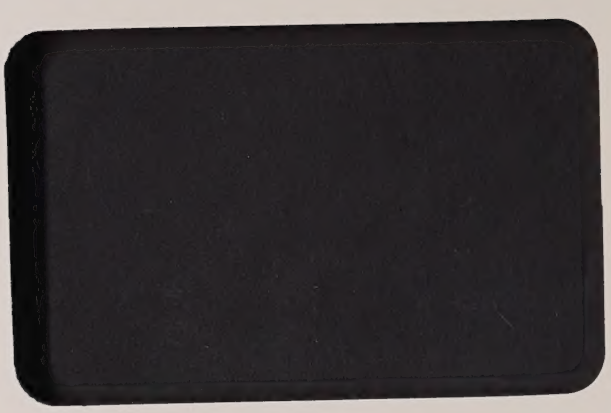
OPERATING AND SERVICING MANUAL

FOR

PRIMARY AC CURRENT SHUNT SET MODEL HCS-1

HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN

MEASUREMENT



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OCTOBER 1968

HOLT INSTRUMENT LABORATORIES

OCONTO, WISCONSIN

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CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also, notify Holt Instrument Laboratories or the local representative immediately. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electron tubes, fuses, and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins if such work is not covered by warranty. All shipments of Holt Instrument Laboratories' equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

SECTION 1
INTRODUCTION

1.1 General Description

a. The Holt Primary AC Current Shunt Set - Model HCS-1 consists of a group of shunts, a shunt transfer unit and the connecting cable. It is designed for the accurate measurement of alternating currents. The Model HCS-1 is designed to be used in conjunction with the Holt Thermal Transfer Voltmeter, Model 6A. The primary function of the Model HCS-1 is to permit accurate comparison of unknown values of AC currents with a corresponding value of DC current whose magnitude is known or can be accurately determined.

b. The Model HCS-1 consists of seven shunt modules which plug directly into the thermal transfer voltmeter. The cable provided connects the shunt modules to the shunt transfer unit. This unit houses the AC to DC transfer switch as well as input terminals for the AC current, the DC current, and the output to the shunt. The shunt transfer unit may be rack mounted or may be provided with its own case. The shunt module set and cable are contained in a walnut finished carrying case. The shunt module set consists of six shunts with fixed resistance values for higher currents, and one shunt module, equipped with a switch, to cover five lower current values.

c. The Model HCS-1 has been designed for use over a frequency range of 5 hertz to 50 hertz.

TECHNICAL SPECIFICATIONS

A C CURRENT SHUNTS - MODEL HCS-1

CURRENT RANGES	10 ma, 25 ma, 50 ma, 100 ma, 250 ma, 500 ma, 1 A, 2.5 A, 5 A, 10 A, and 20 A. Measurements may be made at any point between 50% and 130% of each individual range. The overall range extends from 5 ma to 26 amperes with TV1 Transfer Voltmeter. Limited to 50% to 100% with Models 6 or 6A Transfer Voltmeter.
FREQUENCY CHARACTERISTICS	The accuracy of AC-DC difference for frequencies above 5 Hz and below 50 kHz, including DC, is provided to .02%.
INPUT ADMITTANCE	The input admittance is approximately 1 mho/amp when connected to a Thermal Transfer Standard with 144 ohms input impedance.
TRANSFER SWITCH	Sliding, precious metal switch contacts insure minimum contact resistance. No other switch contacts to affect accuracy. Transfers accomplished to a DC current source equal in magnitude to the AC source. Therefore, the absolute shunt resistance is not of importance.
MECHANICAL	Seven separate shunt modules are provided which plug directly into the Thermal Transfer Voltmeter and are coaxially connected to the shunt transfer unit. These shunt modules are placed in a walnut finished carrying case. The shunt transfer unit can be purchased for either rack mounting or in its own case. This unit houses the AC-DC transfer switch as well as input terminals for AC current, DC current, and output to the shunt.

Figure 1. Primary AC Current Shunts and Transportation Case

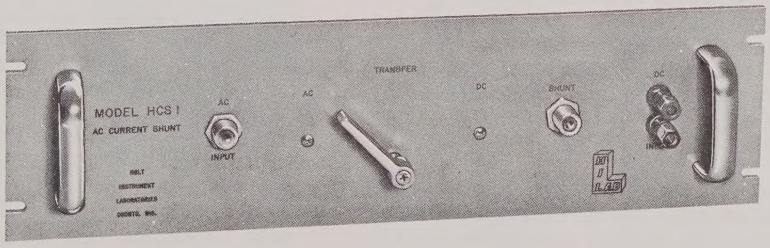


Figure 2. Transfer Panel for Model HCS-1

SECTION 2
OPERATING INSTRUCTIONS

2.1 Preparation for Use

The Primary AC Current Shunt Set, Model HCS-1 is supplied, factory tested and calibrated, in two shipping containers. No power connections other than the circuits under test are required. The Model HCS-1 should require no preliminary service by the customer.

2.2 Operating Controls

The controls and terminals on the Model HCS-1 are described below. These are the controls used in the normal operation of the shunt set, and include those on the front panel of the shunt transfer unit and on the low current shunt. There are no internal adjustments or controls in the shunt set.

a. AC Input - a UHF receptacle for coaxial connection to the AC current source.

b. DC Input - a pair of binding posts for connection to the DC current source. Red post must be connected to DC positive, black post to negative and circuit ground.

c. Shunt - a UHF receptacle for coaxial connection to the shunt module.

d. Transfer Switch - connects the AC source and shorts the DC source when in the left hand position. Connects the DC source and shorts the AC source when in the right hand position. At no position are either AC or DC sources open circuited.

CAUTION

The HCS-1 is designed for use with current regulated supplies. If voltage regulated supplies are used, steps must be taken to insure that the short circuiting action of the transfer switch does not damage the voltage supply. See paragraph 2.3 b.

e. Shunt Module Switch - a five position switch located on the front of the low current shunt module. This switch selects the internal resistor for the 10, 25, 50, 100, or 250 milliampere shunt.

2.3 Applications

a. General. When using the HCS-1 for current measurements, the proper shunt module is connected to the front panel of the Holt Model 6A Thermal Transfer Voltmeter. Consult the manual supplied with this equipment before attempting measurements. In addition to the thermal voltmeter mentioned above, the Model HCS-1 requires certain other external equipment as follows:

(1) DC Supply. A stable, current regulated, DC supply with variable output voltage and sufficient current capacity is required. If a current regulated supply is not available, a voltage regulated supply may be used with a protective series resistor to control current flow.

(2) DC Measuring Equipment. The accuracy with which the DC current can be measured is a determining factor in the accuracy of the system. A precision shunt, standard cell voltbox and potentiometer system is recommended. The recommended precision shunts are listed in the table below.

(3) AC Supply. A stable voltage regulated supply such as the Holt Model 323C is required if calibration and frequency response measurements are to be conducted. A series current limiting resistor must be used with the voltage regulated supply.

b. Using the Model HCS-1. The versatility of the Model HCS-1 has no limit as long as the operator recalls that it will give the same indication, within specifications, for any AC or DC current.

High degrees of accuracy are possible if certain precautions are taken. Keep external lead lengths as short as possible. Small amounts of drift, due to self-heating, can be averaged. For instance: Balance DC, wait time "T"; Balance AC, wait time "T" and return and read DC. The difference between the first and last DC reading is due to drift. Average the two readings and subtract the AC reading for most accurate results. Although the error due to drift is seldom over .02%, it can be all but eliminated by using the above procedure.

TABLE I
RECOMMENDED PRECISION SHUNTS

RESISTANCE	CURRENT	PART NUMBER	MANUFACTURER
0.01 ohm	30 amp	N100-2A8	Otto Wolff
0.1	10	N100-1A7	Otto Wolff
1.0	3.3	N100-1A6	Otto Wolff
10	1.0	N100-1A5	Otto Wolff
100	0.03	4030B	Leeds & Northrup
1000	0.01	4035B	Leeds & Northrup

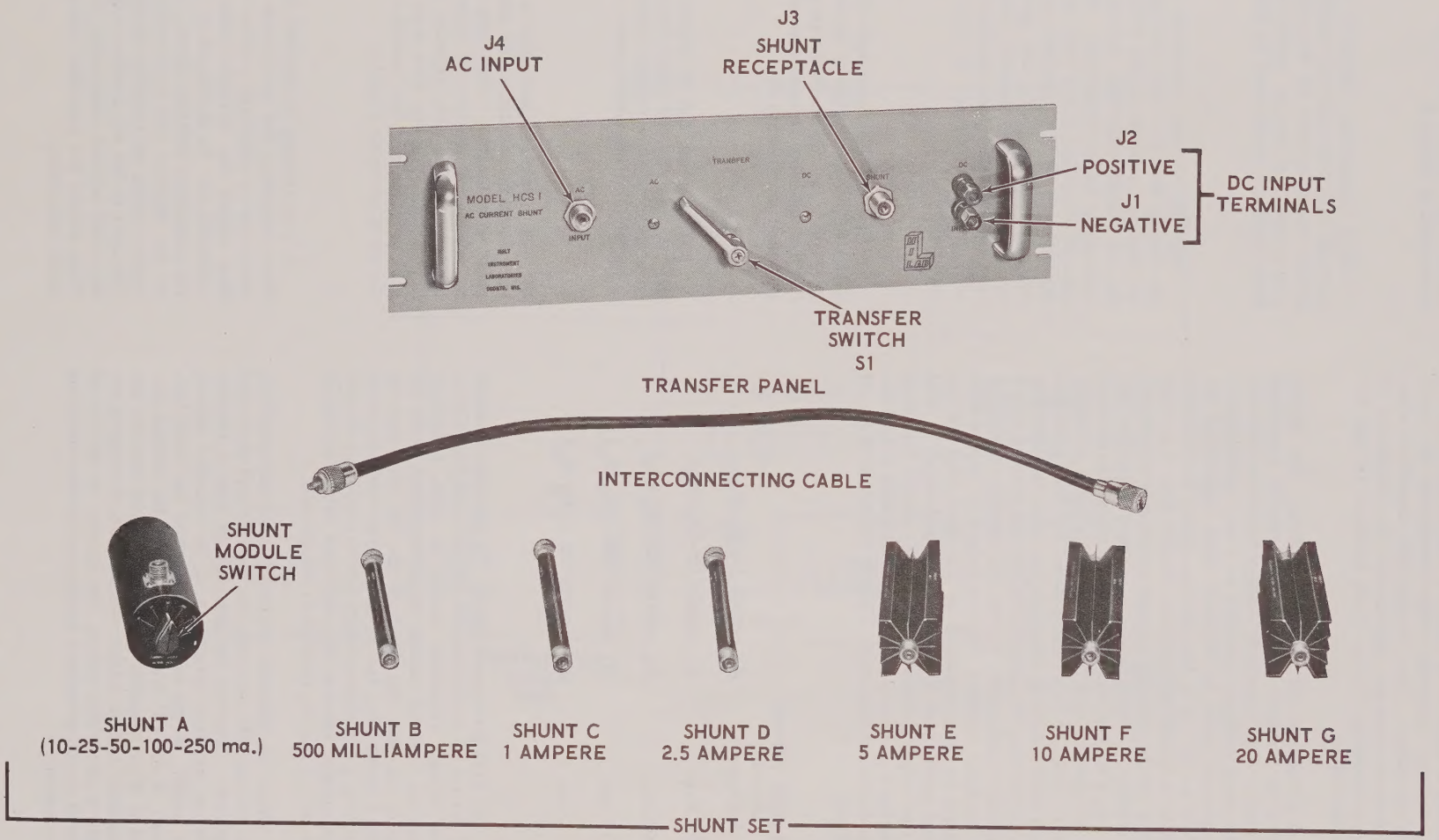


Figure 3. Operating Controls and Terminals

It is further recommended that any transfer be repeated a number of times to insure precision of the reading. Average these results for the most accurate value. This is especially important when the desired accuracy approaches the resolution of the galvanometer or the drift between AC and DC measurements.

c. Protection of Voltage Sources. The Model HCS-1 is designed for use with current regulated sources or high impedance voltage regulated sources. When using voltage regulated sources, some general precautions must be followed when connecting the unit to an AC or a DC source. When the transfer switch is turned to the right, the DC source is connected to the reading equipment and the AC source is shorted. When using a voltage regulated AC source, a series resistor must be connected between the AC source and the meter under test. A decade power resistor is recommended for this purpose. Using such a decade resistor, the total resistance in the circuit may be adjusted so that the current bears a simple relationship to the AC supply voltage. If the limiting resistor (R_L) is properly chosen with respect to the resistance of the shunt (R_S) and the meter under test (R_X), the calibrated output dial or the output voltmeter of the AC source will read directly in amperes or milliamperes with a reasonable degree of accuracy. Choose the value of R_L as follows:

Full scale current of meter	
3 amps	R_L equals $1 - (R_S+R_X)$
1 amp	R_L equals $10 - (R_S+R_X)$
100 ma.	R_L equals $100 - (R_S+R_X)$
10 ma.	R_L equals $1000 - (R_S+R_X)$
1 ma.	R_L equals $10K - (R_S+R_X)$

The Holt Instrument Model 275 current regulated DC source is recommended for use with the HCS-1. If a voltage regulated source is used, a similar dropping resistor should be incorporated in the DC circuit so that the total of the DC shunt and the HCS-1 shunt plus the series decade resistor would result in a resistance which would produce a simple relationship between the regulated output voltage of the supply and the current in the circuit.

When the transfer switch is at its mid-position, the AC and DC sources are shorted and connected together. Connect the sources in such a manner that the common terminals of the transfer switch, the shield of the coaxial cable and the black terminal of the DC connection are in the ground circuit of their respective supplies. If the sources are connected in this manner with the series dropping resistors described above, the current in the circuit should not be excessive during the transfer switching procedure.

d. Current Measurements (up to 10 kHz). A typical test set-up for current measurements is illustrated in figure 4.

When measuring currents up to 10 kHz, the current sources must be capable of supplying the power requirements of the shunt, the instrument under test, and the DC precision shunt. No additional leakage losses need be considered.

With the circuit connected as in figure 4, set the Model 6A at 1 volt AC operation. Select the AC and put with the shunt transfer switch. Adjust the AC source for the desired indication on the instrument being calibrated. Adjust the Model 6A balance controls for a null on the galvanometer. Transfer to the DC position of the shunt transfer switch and adjust for galvanometer balance by varying the DC source. Measure the DC current with the precision shunted potentiometer. The AC current at balance is equal to the DC current as measured.

e. Current Measurements (10 to 50 kHz). The Model HCS-1 is capable of measurements to 50 kHz. Procedure is the same as in paragraph d. above. Certain external errors occur at higher frequencies and must be considered.

(1) Losses due to wiring inductance between the sources and the shunt become large enough to be a factor. The voltage sources must be capable of supplying these added power requirements.

(2) Leakage capacities in the output of the AC sources may unbalance the output. Use extremely short wire lengths. After each reading, interchange the shunt and instrument under test and repeat the reading. If the data repeats, the leakage capacity is negligible; if the data does not repeat, leakage is a problem and the readings should be averaged for most accurate results.

f. Establishing a Desired Absolute AC Current. When adjusting the calibration of an ammeter, it is desirable to establish a given absolute current and then adjust the variable shunt in the ammeter to calibrate it. To do this, it is necessary to reverse the procedure detailed above. Adjust the DC current to the desired full scale value. Null the galvanometer using the transfer standard balance controls. Transfer to the AC position and adjust the AC source for a null without rebalancing the transfer standard. Then adjust the ammeter being tested for this full scale deflection.

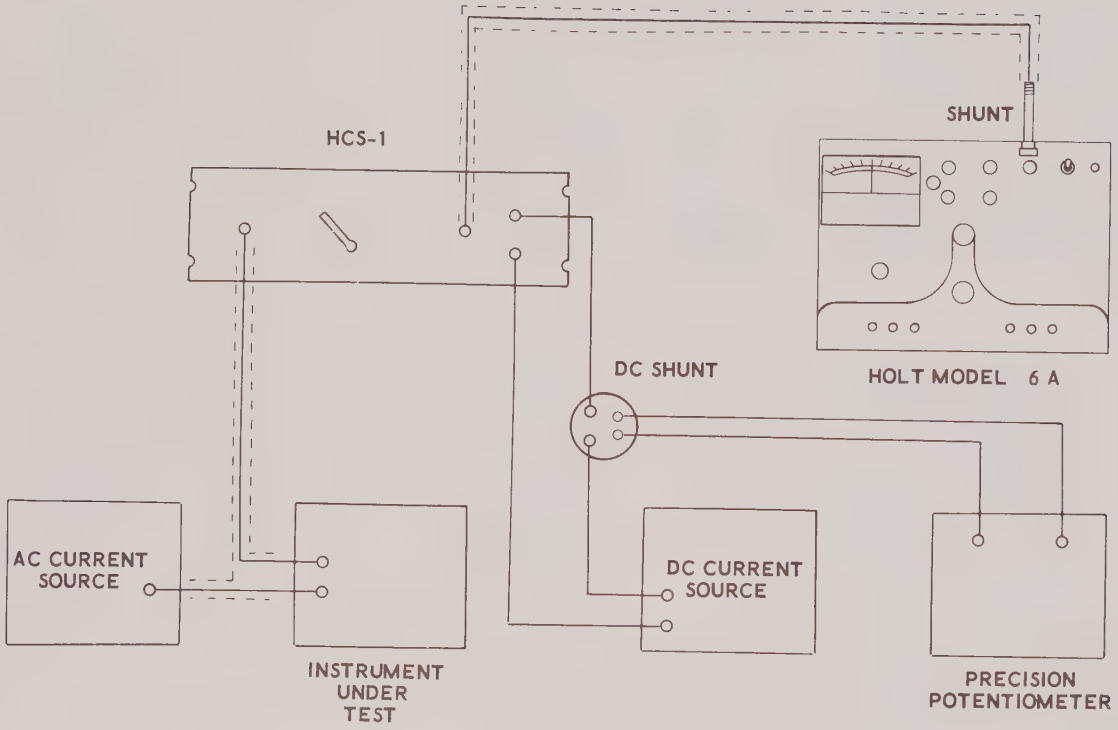


Figure 4. Typical Use of Model HCS-1 Shunts

SECTION 3
THEORY OF OPERATION

3.1 General Theory

The block diagram (figure 5) illustrates the basic operation of the Model HCS-1. The shunt set basically consists of a shunt and transfer switch. The transfer switch permits the shunt to be placed into the AC circuit under test, or into a DC circuit which is used for comparison and whose current flow can be accurately measured.

The Thermal Transfer Voltmeter is connected across the shunt and is used to balance the AC and DC currents by comparing their respective voltage drops. The HCS-1 shunts are designed to have a nominal 1 volt drop when carrying their rated current. The thermal transfer voltmeter is used as an indicating device to determine when the AC and DC drops are identical. Since accuracy of measurement depends on the accuracy with which the voltage drops are matched, rather than on the absolute value of the voltage drop, the exact resistance value of the shunt has no bearing on the accuracy of measurement. When the voltage drops are equal, the currents are equal. The DC current can then be accurately measured. The AC current is, of course, equal to the measured DC value.

3.2 Basic Circuit Theory

a. General. The internal circuitry of the components which make up the Model HCS-1 is essentially simple. Schematic diagrams of the components are largely self-explanatory and will be found at the back of the manual. The following paragraphs are devoted to an explanation of those electrical and mechanical features which are peculiar to the Model HCS-1 or which require some precautions while in use.

b. Transfer Panel. A schematic of the transfer panel will be found at the back of the manual. Essentially, the transfer panel is a two section switch. One section transfers the shunt from the AC to the DC circuit; the other section is designed to short out the terminals not connected to the shunt thus maintaining a load on the constant current sources. Because of this switching characteristic, precautions must be taken if the unit is used with constant voltage regulated sources instead of constant current sources. In addition, the ground circuits of the two instruments must be at the same potential to avoid excessive current in the ground circuit during the switching transient. See paragraph 2.3 c. for detailed precautions.

c. Low Current Shunt. A schematic of the switch and shunt connection contained in the low current shunt will be found at the back of the manual. This shunt has no internal adjustments and contains no replaceable parts. It is recommended that it be returned to Holt Instrument Laboratories if any repairs or parts replacements are indicated.

d. High Current Shunts. Each of the high current shunts contain a single shunt resistor. The 5, 10, and 20 ampere shunts have fins for greater heat dissipation. Each shunt must dissipate one watt for each ampere applied at rated current. The .5, 1, and 2.5 ampere shunts are potted in 5/8-inch diameter tubes.

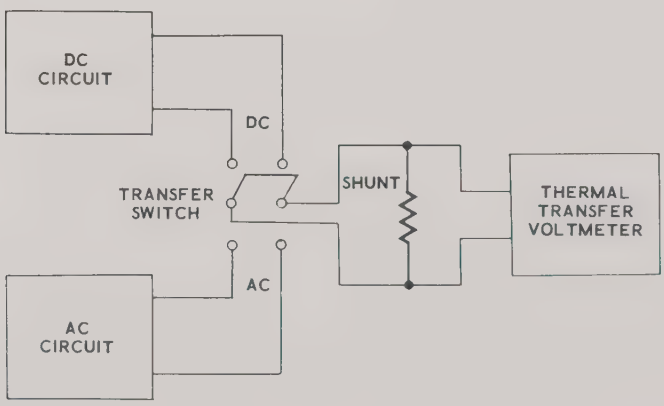


Figure 5. Model HCS-1 Block Diagram

SECTION 4
RECALIBRATION AND SERVICING

4.1 Recalibration

There are no recalibration adjustments to be made on any of the shunts or the Transfer Switch. All components are fixed, passive types, factory selected for proper performance. Under normal conditions there is no deterioration of performance with age when proper handling precautions are observed and the shunts are operated within specified current limits. The shunts are usually checked for AC-DC difference by comparison with a set of shunts which have been submitted to NBS for testing. These tests can only be conducted in a properly equipped standards laboratory that has the test fixtures and special test equipment to perform the tests. It is recommended that AC-DC difference tests be made by NBS or Holt Instrument Laboratories. Both are properly instrumented to make these tests.

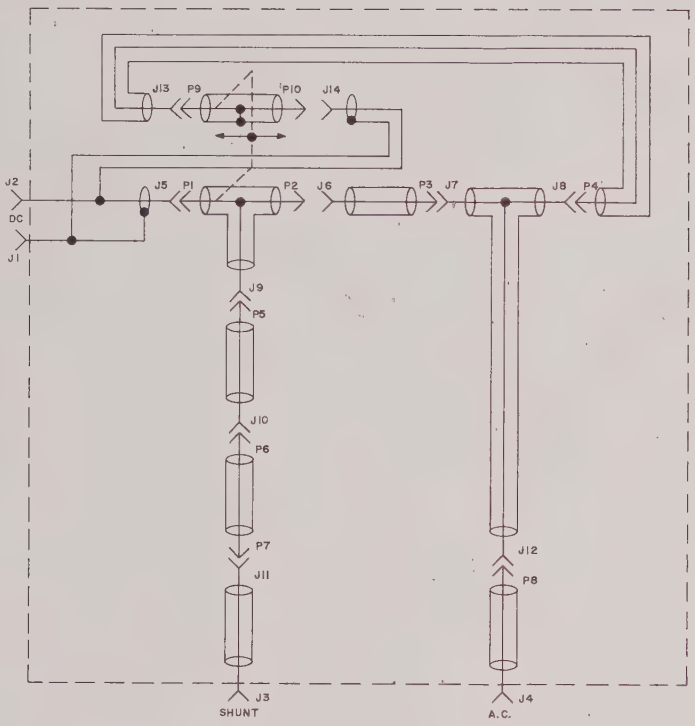
4.2 Service

Service is restricted to a simple procedure. Refer to the schematic diagrams at the rear of the manual. Check the resistance of the modules as listed in the table. The transfer switch may be checked for continuity and proper switching sequence. The switching action is make-before-break. When in the center of its switch travel, both inputs are shorted together and to common.

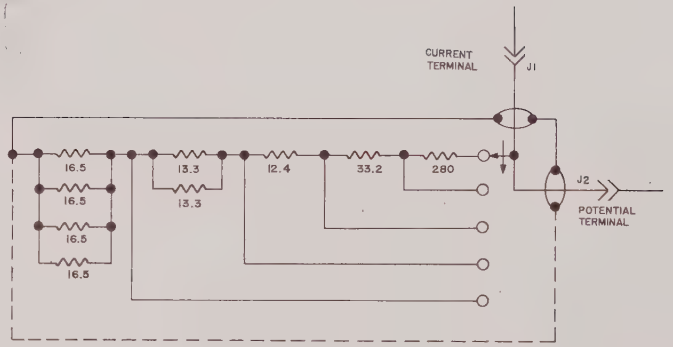
There are no replaceable parts listed for the shunts, and only the input connectors are listed for the transfer switch. Service or repair of any of the shunts may result in performance being out of specification limits. Internal components and wiring are factory selected and adjusted to meet specified performance. Units should be returned to Holt Instrument Laboratories for service if it is required.

LIST OF REPLACEABLE PARTS
A. C. CURRENT SHUNTS - MODEL HCS-1

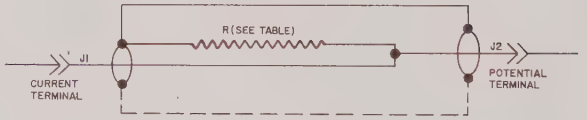
Circuit Reference	Description	Holt Part Number	Manuf.	Catalog Number	Location Figure No.
	Shunt A, 10-250 MA	81664	Holt		3
	Shunt B, 500 MA	81667-001	Holt		3
	Shunt C, 1 A	81667-002	Holt		3
	Shunt D, 2.5 A	81667-003	Holt		3
	Shunt E, 5 A	81668-001	Holt		3
	Shunt F, 10 A	81668-002	Holt		3
	Shunt G, 20 A	81668-003	Holt		3
	Interconnecting Cable	83429	Holt		3
	Transportation Case	52524			1
J1	Terminal, Binding Post, Black	1803-017	Superior	DF30BC	3
J2	Terminal, Binding Post, Red	1803-018	Superior	DF30RC	3
J3 & J4	Connector, Coaxial, UHF	1703-006	Amphenol	UG-363/U	3
S1	Switch Assembly	81630	Holt		3



TRANSFER SWITCH SCHEMATIC



"A" SHUNT, SHOWN IN 10 ma POSITION



B, C, D, E, F, G, SHUNTS

SHUNT	RATING	NOTE 1	RESISTANCE
A	10 ma	100 OHMS	333 OHMS
	25 ma	40 "	55.6 "
	50 ma	20 "	23.2 "
	100 ma	10 "	10.77 "
	250 ma	4.0 "	4.11 "
B	500 ma	2.0 "	2.03 "
C	1 amp	1.0 "	1.01 "
D	2.5 amp	.40 "	.401 "
E	5 amp	.20 "	.2003 "
F	10 amp	.10 "	.1001 "
G	20 amp	.05 "	.05 "

NOTE:

A- WHEN CONNECTED TO COMPANION AC-DC THERMAL TRANSFER STANDARD RER INSTRUCTIONS. (TOLERANCE ± 5%)

EFFECTIVE SERIAL NO _____

SCHEMATIC DIAGRAM

MODEL HCS-1

HOLT INSTRUMENT LABORATORIES

DCONTO WISCONSIN

OPERATING AND SERVICING MANUAL

FOR

MODEL HCS-1

ALTERNATING CURRENT SHUNTS

HOLT INSTRUMENT LABORATORIES

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Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins if such work is not covered by warranty. All shipments of Holt Instrument Laboratories' equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

TECHNICAL SPECIFICATIONS

Designed As A Companion Unit For The Holt Thermal Transfer Voltmeter, Model TVI

Current Ranges: 10 ma, 25 ma, 50 ma, 100 ma, 250 ma, 500 ma, 1 amp, 2.5 amp, 5 amp, 10 amp and 20 amp. Measurement made at any point between 50% and 130% of each individual range. The overall range therefore extends from 5 ma to 26 amperes.

Frequency Characteristic: For frequencies above 5 cps and below 50 kc and DC, the AC-DC difference of each shunt at its rated current will not exceed .02%.

Transfer Switch: Included: A precious metal, sliding contact transfer switch which shorts out the current source not in use and applies the output of the other to the selected current shunt. Transfers are accomplished to a DC source of equal magnitude to the AC source. Therefore, absolute shunt resistance is not important.

Mechanical: Seven separate shunt modules are provided which plug directly into the TVI and are coaxially connected to the shunt transfer unit. The transfer unit can be purchased for either rack mounting or in its own case. This unit houses the transfer switch as well as the AC and DC input current terminals.

SECTION I

GENERAL DESCRIPTION

I-1 Description:

The AC shunt modules are coaxial, four terminal resistors designed with a minimum of self-inductance so that their AC-DC difference is small even at frequencies up to 50 KC. They are provided with UHF type connectors to provide easy connection. The potential terminals (male UHF) plug into the TVI. The current terminals (female UHF) connect through the transfer panel to the current sources.

The output potential will equal 1 volt for rated current through the shunt. It is necessary to use regulated current sources with some power capabilities. Each shunt is capable of and requires 1 watt of power for every ampere applied. That is: The 20 amp shunt at full power dissipates 20 watts. The 5 amp shunt at full power dissipates 5 watts.

Since equal AC and DC currents are required in this transfer technique, the absolute resistance of the shunt need not be known as long as it remains constant (within the specifications) for either AC or DC during the time required to make a transfer.

SECTION II

OPERATION

2-1 Terminals and Controls - Transfer Panel:

AC Input: To the left of the center of the transfer panel a UHF receptacle permits coaxial connection to the AC current source.
DC Input: To the right of the center of the transfer panel a red and a black binding post permit connection to the source of DC current.
Transfer Switch: Located in center of the transfer panel, this bar handle switch connects the shunt to the AC source and shorts the DC source when activated to the left. When depressed to the right it connects the DC source to the shunt and shorts out the AC source. At no position are either of the sources open circuited.
Shunt Cable: To the right of the transfer switch a cable grip holds the shunt cable. This cable connects the transfer panel to the selected current shunt.

2-2 The Shunts:

Each Model HCS-1 consists of seven shunt modules. The 10 ampere and 20 ampere modules have fins for greater heat dissipation. The 5 ampere and 2.5 ampere are 5/8 inch tubes in which the shunt element is potted. The .5 ampere and 1 ampere are 1½ inch tubes not potted. The low current module is 2-5/8 inches in diameter and contains all of the 10 ma, 25 ma, 50 ma, 100 ma and 250 ma (low current) ranges. Each of the low current ranges may, in turn, be selected with the switch provided on the end of the module.

2-3 Operation Up To 10 KC:

To measure currents of frequencies up to 10 KC, the current sources employed must be capable of providing power to the shunt, the instrument under test and the DC precision shunt. No other losses need be accounted for. (See Figure 2-1).

Set the TVI at 1 volt, operate AC, and plug the shunt into the TVI AC input terminal. Connect the shunt to the transfer panel with the cable marked "shunt". Connect the series circuit of the AC source and the AC current instrument under test into the AC input terminal on the HCS-1 transfer panel. Connect the series circuit consisting of the DC current source and the precision DC shunt to the DC input terminals of the HCS-1 transfer panel.

Select the AC input with the transfer switch, and adjust the source for TVI galvanometer null at approximately 100% (balance control setting). Transfer to DC

and re-perform the balance by adjusting the DC source. The DC current can be measured with the DC shunt and precision potentiometer. The AC current is equal to the DC current as measured.

To calibrate AC ammeters it may be necessary to work "backwards". Null the galvanometer for a DC current which would be the full scale ammeter reading. Transfer to AC and adjust the AC source for null without rebalancing. Then adjust the ammeter being tested for full scale deflection.

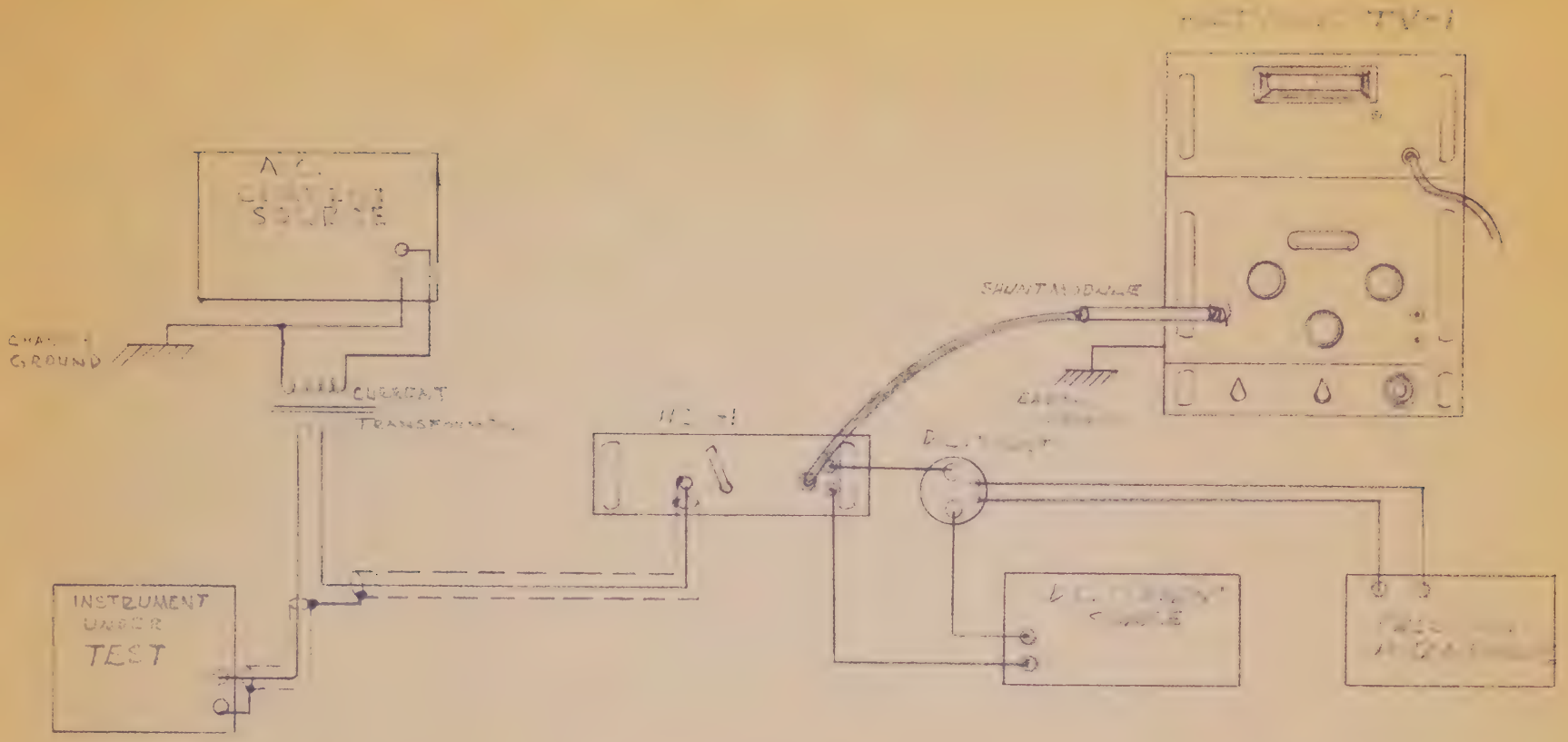
The versatility of the HCS-1 has no limit as long as the operator recalls that it will give the same indication, within specifications, for any AC or DC current.

Higher degrees of accuracy are available if certain precautions are taken. Keep external lead lengths as short as possible. Small amounts of drift, due to self-heating, can be averaged. For instance: Balance DC, wait time "T"; Balance AC, wait time "T" and return and read DC. The difference between the first and last DC reading is due to drift. Average the two readings and subtract the AC reading for most accurate results. Although the error due to drift is seldom over .02% it can be all but eliminated by using the above procedure.

It is further recommended that any transfer be repeated a number of times to insure repeatability of the reading. Then average these results for most accurate readings. This is especially important when reading accuracies are extremely small, or where reading error alone may provide a large portion of the error.

2-4 Operation 10 KC to 50 KC:

The Model HCS-1 as shipped is capable of AC accuracy up to 50 KC. However, a number of external errors occur which will affect the accuracy of your readings. First, there is more loss due to wiring inductance between the sources and the shunt. Therefore, sources of greater power capabilities are required. Secondly, leakage capacity in the output of the AC current sources may unbalance the output. For best results up to 50 KC use extremely short wire lengths and after each reading interchange the shunt and the instrument under test and repeat the reading. If data repeats, then leakage capacity is negligible. If data does not repeat, leakage is a problem and results should be averaged for accurate readings.



MAT

FIN

TOLERANCE

HCS-1

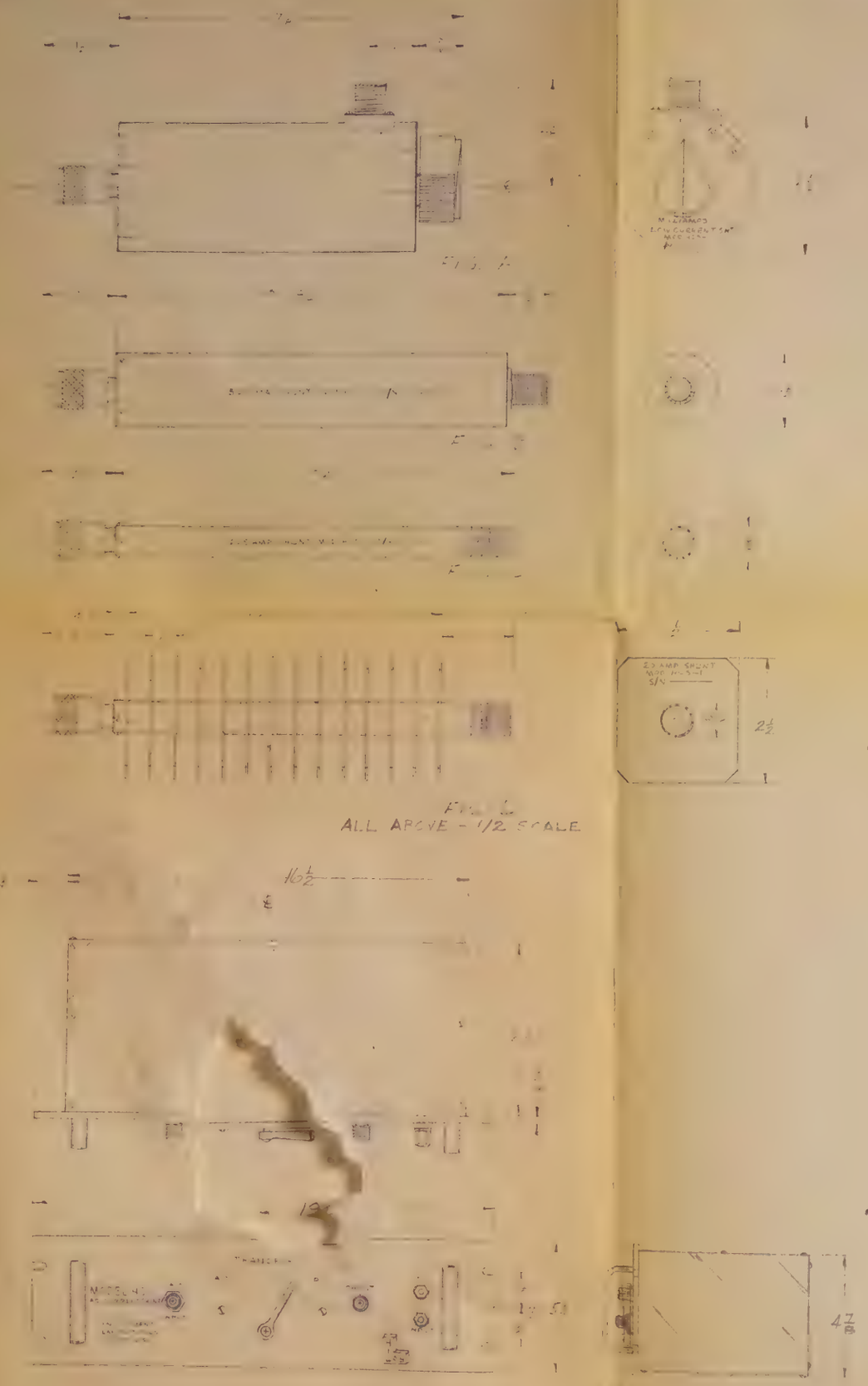


FIGURE E
1/4 SCALE

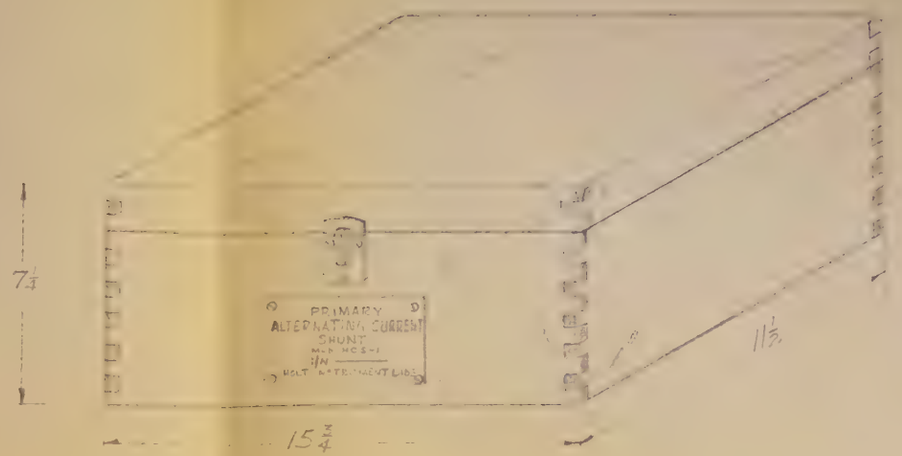


FIGURE F
1/4 SCALE

1. DESIGNED AS A COMPANION UNIT FOR HOLT MODEL TV-1

2. CURRENT RANGES: 10MA, 25 MA, 50MA, 100MA, 250 MA, 500MA, 1 AMP, 2.5 AMP, 5 AMP, 10 AMP, 20 AMP. MEASUREMENTS CAN BE MADE AT ANY POINT BETWEEN 50% & 130% OF EACH RANGE. THE OVERALL RANGE, THEREFORE, EXTENDS FROM 5 MA TO 26 AMPERES.

3. FREQUENCY RANGE: FOR FREQUENCIES ABOVE 5 CPS AND BELOW 50KC AND D.C., THE AC-DC DIFFERENCE WILL NOT EXCEED .02%

4. TRANSFER SWITCH: PRECIOUS METAL SHUNTING CONTACT WITH EXTREMELY LOW DETECTABLE RESISTANCE INCLUDED. THE SWITCH SHORTS THE UNUSED CURRENT SOURCE AND APPLIES THE OTHER TO THE SHUNT. TRANSFERS ACCOMPLISHED TO SOURCES OF EQUAL MAGNITUDE.

5. CURRENT SOURCE POWER REQUIREMENT: APPROX. 1 WATT PER AMPERE.

6. OUTPUT: APPROX. 1 VOLT @ RATED CURRENT.

7. TERMINALS: ALL STANDARD UHF CONNECTORS FOR A.C., ALL PURPOSE BINDING POSTS

8. MECHANICAL:

					ASSEMBLY #	SUB ASSY
A	1 AMP CURRENT SHUNT				81664	A
B	500MA CURRENT SHUNT		1	4	81665	B
B	250MA CURRENT SHUNT			1	81665	C
C	100MA "	"			81667	D
D	50MA "	"	2	3	81668	E
D	"	"			81669	F
D	"	"	2	2	81668	G
E					81667	
F			9	1	81121	

HOLT CASE - LIKE (TRANSFERABLE TO N.B.S.) - UPON REQUEST
N.B.S. CASE - AS PER MANUFACTURERS DRAWING TO N.B.S.

TOTAL SHIPPING WEIGHT - APPROX. 45 LBS

HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN

MAT'L	DATE	MODEL	
FIN	APPROVED		
TOLERANCE UNLESS NOTED — FRACT — DEC —	SCALE	DRFT	DRAWING NO	CHNG B

C.2

OPERATING AND SERVICING MANUAL

FOR

PRIMARY AC CURRENT SHUNT SET MODEL HCS-1

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FEBRUARY 1965

HOLT INSTRUMENT LABORATORIES

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CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also, notify Holt Instrument Laboratories or the local representative immediately. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electron tubes, fuses, and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins if such work is not covered by warranty. All shipments of Holt Instrument Laboratories' equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

SECTION 1
INTRODUCTION

1.1 General Description

a. The Holt Primary AC Current Shunt Set - Model HCS-1 consists of a group of shunts, a shunt transfer unit and the connecting cable. It is designed for the accurate measurement of alternating currents. The Model HCS-1 is designed to be used in conjunction with the Holt Thermal Transfer Voltmeter, Model TV-1 or Model 6. The primary function of the Model HCS-1 is to permit accurate comparison of unknown values of AC currents with a corresponding value of DC current whose magnitude is known or can be accurately determined.

b. The Model HCS-1 consists of seven shunt modules which plug directly into either of the thermal transfer voltmeters. The cable provided connects the shunt modules to the shunt transfer unit. This unit houses the AC to DC transfer switch as well as input terminals for the AC current, the DC current, and the output to the shunt. The shunt transfer unit may be rack mounted or may be provided with its own case. The shunt module set and cable are contained in a walnut finished carrying case. The shunt module set consists of six shunts with fixed resistance values for higher currents, and one shunt module, equipped with a switch, to cover five lower current values.

c. The Model HCS-1 has been designed for use over a frequency range of 5 cycles per second to 50 kilocycles.

TECHNICAL SPECIFICATIONS

A C CURRENT SHUNTS - MODEL HCS-1

CURRENT RANGES	10 ma, 25 ma, 50 ma, 100 ma, 250 ma, 500 ma, 1 A, 2.5 A, 5 A, 10 A, and 20 A. Measurements may be made at any point between 50% and 130% of each individual range. The overall range extends from 5 ma to 26 amperes. with TVI Transfer Voltmeter. Limited to 50% to 100% with Models 6 or 6A Transfer Voltmeter.
FREQUENCY CHARACTERISTICS	The accuracy of AC-DC difference for frequencies above 5 cps and below 50 kc, including DC, is provided to .02%.
TRANSFER SWITCH	Sliding, precious metal switch contacts insure minimum contact resistance. No other switch contacts to affect accuracy. Transfers accomplished to a DC current source equal in magnitude to the AC source. Therefore, the absolute shunt resistance is not of importance.
MECHANICAL	Seven separate shunt modules are provided which plug directly into the Thermal Transfer Voltmeter and are coaxially connected to the shunt transfer unit. These shunt modules are placed in a walnut finished carrying case. The shunt transfer unit can be purchased for either rack mounting or in its own case. This unit houses the AC-DC transfer switch as well as input terminals for AC current, DC current, and output to the shunt.

Figure 1. Primary AC Current Shunts and Transportation Case

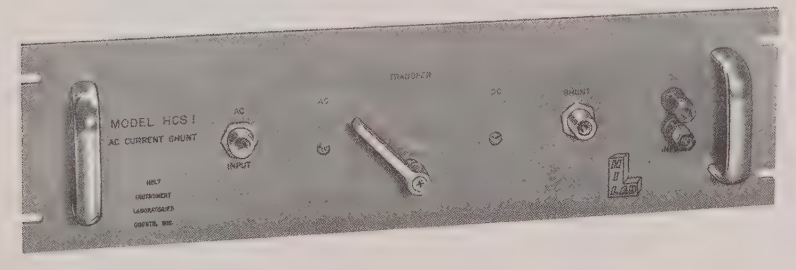


Figure 2. Transfer Panel for Model HCS-1

SECTION 2
OPERATING INSTRUCTIONS

2.1 Preparation for Use

The Primary AC Current Shunt Set, Model HCS-1 is supplied, factory tested and calibrated, in two shipping containers. No power connections other than the circuits under test are required. The Model HCS-1 should require no preliminary service by the customer.

2.2 Operating Controls

The controls and terminals on the Model HCS-1 are described below. These are the controls used in the normal operation of the shunt set, and include those on the front panel of the shunt transfer unit and on the low current shunt. There are no internal adjustments or controls in the shunt set.

a. AC Input - a UHF receptacle for coaxial connection to the AC current source.

b. DC Input - a pair of binding posts for connection to the DC current source. Red post must be connected to DC positive, black post to negative and circuit ground.

c. Shunt - a UHF receptacle for coaxial connection to the shunt module.

d. Transfer Switch - connects the AC source and shorts the DC source when in the left hand position. Connects the DC source and shorts the AC source when in the right hand position. At no position are either AC or DC sources open circuited.

CAUTION

The HCS-1 is designed for use with current regulated supplies. If voltage regulated supplies are used, steps must be taken to insure that the short circuiting action of the transfer switch does not damage the voltage supply. See paragraph 2.3 b.

e. Shunt Module Switch - a five position switch located on the front of the low current shunt module. This switch selects the internal resistor for the 10, 25, 50, 100, or 250 milliampere shunt.

2.3 Applications

a. General. When using the HCS-1 for current measurements, the proper shunt module is connected to the front panel of either the Holt Model 6 or the Holt Model TV-1 Thermal Transfer Voltmeter. Consult the manual supplied with this equipment before attempting measurements. In addition to the thermal voltmeters mentioned above, the Model HCS-1 requires certain other external equipment as follows:

(1) DC Supply. A stable, current regulated, DC supply with variable output voltage and sufficient current capacity is required. If a current regulated supply is not available, a voltage regulated supply may be used with a protective series resistor to control current flow.

(2) DC Measuring Equipment. The accuracy with which the DC current can be measured is a determining factor in the accuracy of the system. A precision shunt, standard cell voltbox and potentiometer system is recommended. The recommended precision shunts are listed in the table below.

(3) AC Supply. A stable, current regulated, adjustable, variable frequency supply such as the Holt Model ACS-200 or a voltage regulated supply such as the Holt Model 323A is required if calibration and frequency response measurements are to be conducted. A series current limiting resistor must be used with the voltage regulated supply.

b. Using the Model HCS-1. The versatility of the Model HCS-1 has no limit as long as the operator recalls that it will give the same indication, within specifications, for any AC or DC current.

High degrees of accuracy are possible if certain precautions are taken. Keep external lead lengths as short as possible. Small amounts of drift, due to self-heating, can be averaged. For instance: Balance DC, wait time "T"; Balance AC, wait time "T" and return and read DC. The difference between the first and last DC reading is due to drift. Average the two readings and subtract the AC reading for most accurate results. Although the error due to drift is seldom over .02%, it can be all but eliminated by using the above procedure.

TABLE I
RECOMMENDED PRECISION SHUNTS

RESISTANCE	CURRENT	PART NUMBER	MANUFACTURER
0.01 ohm	30 amp	N100-2A8	Otto Wolff
0.1	10	N100-1A7	Otto Wolff
1.0	3.3	N100-1A6	Otto Wolff
10	1.0	N100-1A5	Otto Wolff
100	0.03	4030B	Leeds & Northrup
1000	0.01	4035B	Leeds & Northrup

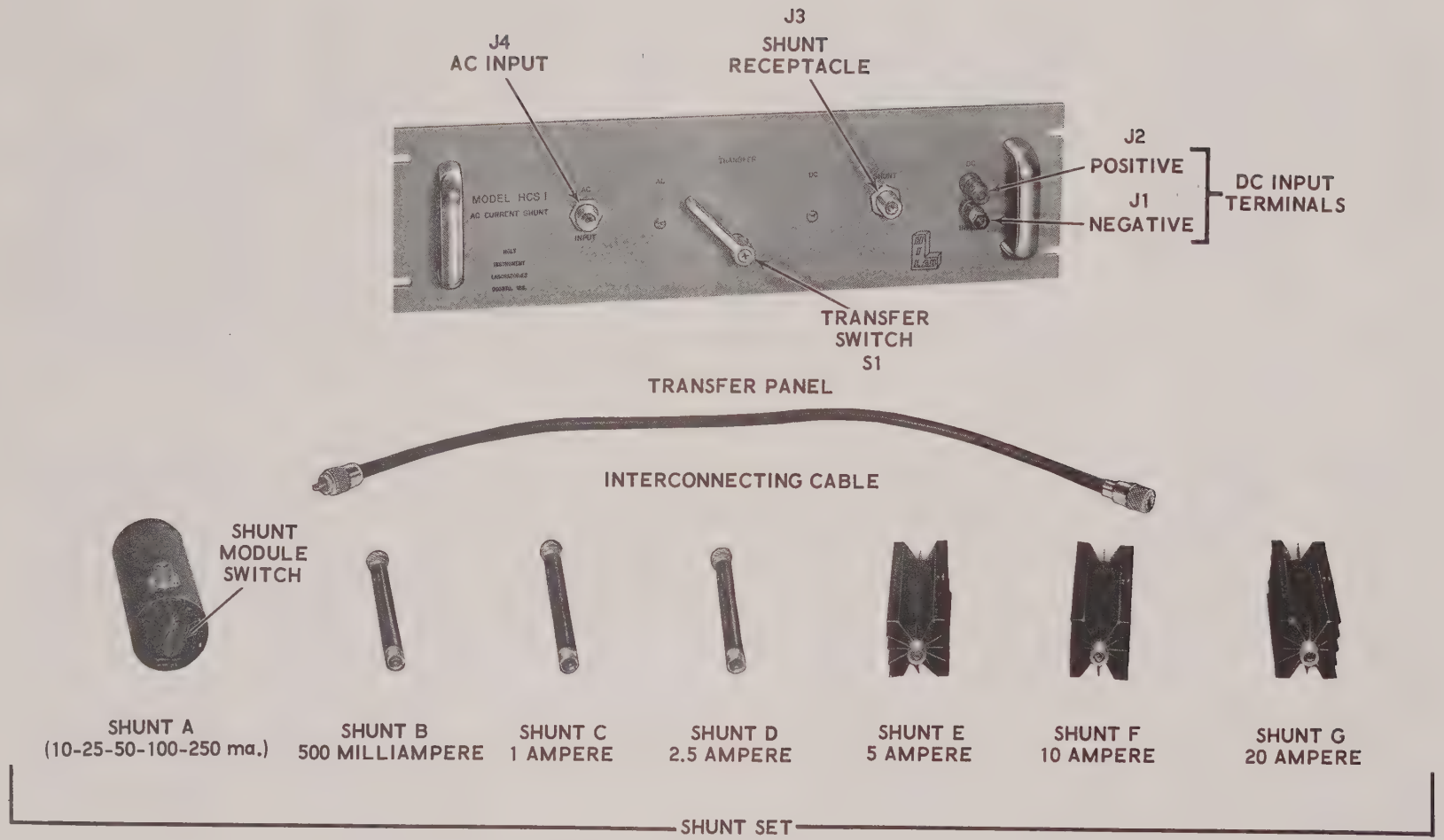


Figure 3. Operating Controls and Terminals

It is further recommended that any transfer be repeated a number of times to insure precision of the reading. Average these results for the most accurate value. This is especially important when the desired accuracy approaches the resolution of the galvanometer or the drift between AC and DC measurements.

c. Protection of Voltage Sources. The Model HCS-1 is designed for use with current regulated sources or high impedance voltage regulated sources. When using voltage regulated sources, some general precautions must be followed when connecting the unit to an AC or a DC source. When the transfer switch is turned to the right, the DC source is connected to the reading equipment and the AC source is shorted. When using a voltage regulated AC source, a series resistor must be connected between the AC source and the meter under test. A decade power resistor is recommended for this purpose. Using such a decade resistor, the total resistance in the circuit may be adjusted so that the current bears a simple relationship to the AC supply voltage. If the limiting resistor (R_L) is properly chosen with respect to the resistance of the shunt (R_S) and the meter under test (R_X), the calibrated output dial or the output voltmeter of the AC source will read directly in amperes or milliamperes with a reasonable degree of accuracy. Choose the value of R_L as follows:

Full scale current of meter	
3 amps	R_L equals $1 - (R_S+R_X)$
1 amp	R_L equals $10 - (R_S+R_X)$
100 ma.	R_L equals $100 - (R_S+R_X)$
10 ma.	R_L equals $1000 - (R_S+R_X)$
1 ma.	R_L equals $10K - (R_S+R_X)$

The Holt Instrument Model 275 current regulated DC source is recommended for use with the HCS-1. If a voltage regulated source is used, a similar dropping resistor should be incorporated in the DC circuit so that the total of the DC shunt and the HCS-1 shunt plus the series decade resistor would result in a resistance which would produce a simple relationship between the regulated output voltage of the supply and the current in the circuit.

When the transfer switch is at its mid-position, the AC and DC sources are shorted and connected together. Connect the sources in such a manner that the common terminals of the transfer switch, the shield of the coaxial cable and the black terminal of the DC connection are in the ground circuit of their respective supplies. If the sources are connected in this manner with the series dropping resistors described above, the current in the circuit should not be excessive during the transfer switching procedure.

d. Current Measurements (up to 10 kc). A typical test set-up for current measurements is illustrated in figure 4.

NOTE

The set-up illustrated employs the Holt Model TV-1. If the Model 6 were used, the arrangement would be similar. The Model 6 requires an external galvanometer and the shunt module would be connected to the special receptacle provided on the Model 6.

When measuring currents up to 10 kc, the current sources must be capable of supplying the power requirements of the shunt, the instrument under test, and the DC precision shunt. No additional leakage losses need be considered.

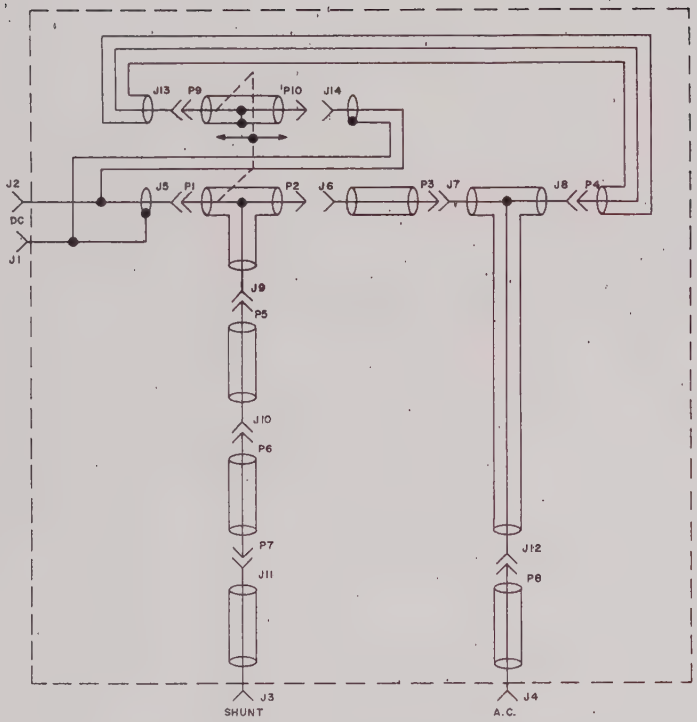
With the circuit connected as in figure 4, set the TV-1 at 1 volt AC operation. Select the AC and put with the shunt transfer switch. Adjust the AC source for the desired indication on the instrument being calibrated. Adjust the TV-1 balance controls for a null on the galvanometer. Transfer to the DC position of the shunt transfer switch and adjust for galvanometer balance by varying the DC source. Measure the DC current with the precision shunted potentiometer. The AC current at balance is equal to the DC current as measured.

e. Current Measurements (10 to 50 kc). The Model HCS-1 is capable of measurements to 50 kc. Procedure is the same as in paragraph d. above. Certain external errors occur at higher frequencies and must be considered.

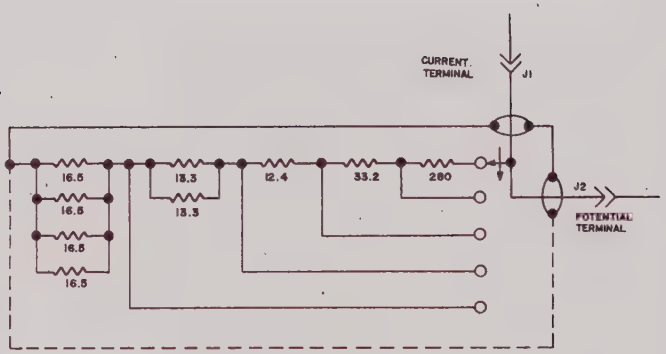
(1) Losses due to wiring inductance between the sources and the shunt become large enough to be a factor. The voltage sources must be capable of supplying these added power requirements.

(2) Leakage capacities in the output of the AC sources may unbalance the output. Use extremely short wire lengths. After each reading, interchange the shunt and instrument under test and repeat the reading. If the data repeats, the leakage capacity is negligible; if the data does not repeat, leakage is a problem and the readings should be averaged for most accurate results.

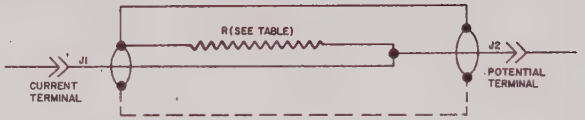
f. Establishing a Desired Absolute AC Current. When adjusting the calibration of an ammeter, it is desirable to establish a given absolute current and then adjust the variable shunt in the ammeter to calibrate it. To do this, it is necessary to reverse the procedure detailed above. Adjust the DC current to the desired full scale value. Null the galvanometer using the transfer standard balance controls. Transfer to the AC position and adjust the AC source for a null without rebalancing the transfer standard. Then adjust the ammeter being tested for this full scale deflection.



TRANSFER SWITCH SCHEMATIC



"A" SHUNT, SHOWN IN 10 ma POSITION



B, C, D, E, F, G, SHUNTS

SHUNT	RATING	NOTE 1	RESISTANCE
A	10 ma	100 OHMS	333 OHMS
	25 ma	40 "	55.6 "
	50 ma	20 "	23.2 "
	100 ma	10 "	10.77 "
	250 ma	4.0 "	4.11 "
B	500 ma	2.0 "	2.03 "
C	1 amp	1.0 "	1.01 "
D	2.5 amp	.40 "	.401 "
E	5 amp	.20 "	.2003 "
F	10 amp	.10 "	.1001 "
G	20 amp	.05 "	.05 "

NOTE:

A- WHEN CONNECTED TO COMPANION AC-DC THERMAL TRANSFER STANDARD PER INSTRUCTIONS. (TOLERANCE ± 5%)

EFFECTIVE SERIAL NO. _____

SCHEMATIC DIAGRAM

MODEL HCS-1

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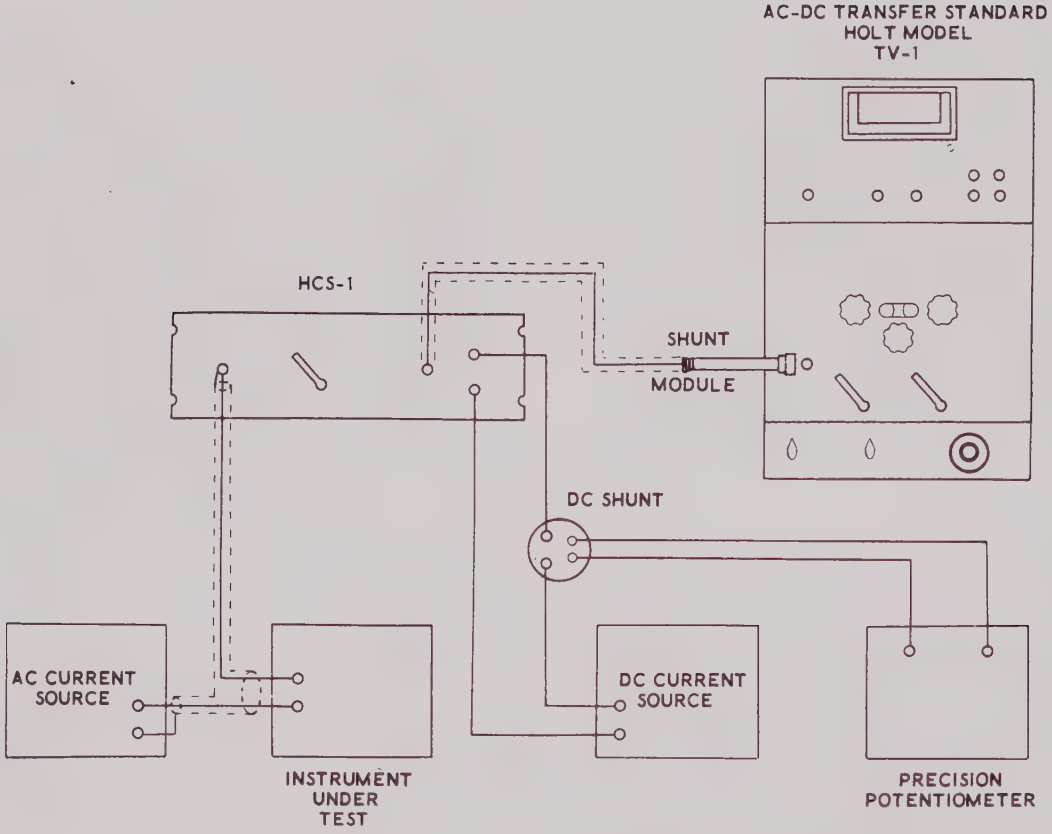

Figure 4. Typical Use of Model HCS-1 Shunts

SECTION 3
THEORY OF OPERATION

3.1 General Theory

The block diagram (figure 5) illustrates the basic operation of the Model HCS-1. The shunt set basically consists of a shunt and transfer switch. The transfer switch permits the shunt to be placed into the AC circuit under test, or into a DC circuit which is used for comparison and whose current flow can be accurately measured.

The Thermal Transfer Voltmeter is connected across the shunt and is used to balance the AC and DC currents by comparing their respective voltage drops. The HCS-1 shunts are designed to have a nominal 1 volt drop when carrying their rated current. The thermal transfer voltmeter is used as an indicating device to determine when the AC and DC drops are identical. Since accuracy of measurement depends on the accuracy with which the voltage drops are matched, rather than on the absolute value of the voltage drop, the exact resistance value of the shunt has no bearing on the accuracy of measurement. When the voltage drops are equal, the currents are equal. The DC current can then be accurately measured. The AC current is, of course, equal to the measured DC value.

3.2 Basic Circuit Theory

a. General. The internal circuitry of the components which make up the Model HCS-1 is essentially simple. Schematic diagrams of the components are largely self-explanatory and will be found at the back of the manual. The following paragraphs are devoted to an explanation of those electrical and mechanical features which are peculiar to the Model HCS-1 or which require some precautions while in use.

b. Transfer Panel. A schematic of the transfer panel will be found at the back of the manual. Essentially, the transfer panel is a two section switch. One section transfers the shunt from the AC to the DC circuit; the other section is designed to short out the terminals not connected to the shunt thus maintaining a load on the constant current sources. Because of this switching characteristic, precautions must be taken if the unit is used with constant voltage regulated sources instead of constant current sources. In addition, the ground circuits of the two instruments must be at the same potential to avoid excessive current in the ground circuit during the switching transient. See paragraph 2.3 c. for detailed precautions.

c. Low Current Shunt. A schematic of the switch and shunt connection contained in the low current shunt will be found at the back of the manual. This shunt has no internal adjustments and contains no replaceable parts. It is recommended that it be returned to Holt Instrument Laboratories if any repairs or parts replacements are indicated.

d. High Current Shunts. Each of the high current shunts contain a single shunt resistor. The 5, 10, and 20 ampere shunts have fins for greater heat dissipation. Each shunt must dissipate one watt for each ampere applied at rated current. The .5, 1, and 2.5 ampere shunts are potted in 5/8-inch diameter tubes.

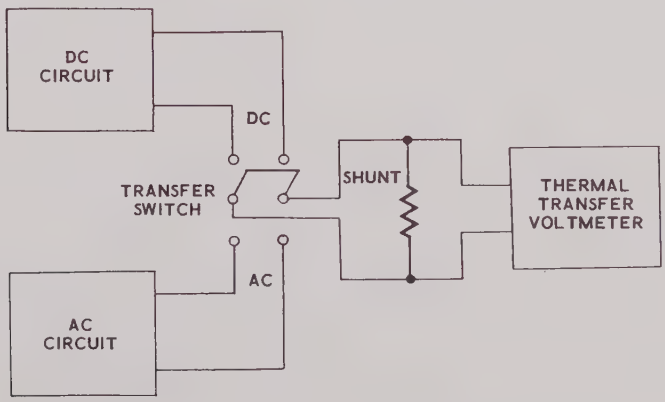

Figure 5. Model HCS-1 Block Diagram

LIST OF REPLACEABLE PARTS
A. C. CURRENT SHUNTS - MODEL HCS-1

Circuit Reference	Description	Holt Part Number	Location Figure No.
	Shunt A, 10-250 MA	81664	3
	Shunt B, 500 MA	81667-001	3
	Shunt C, 1 A	81667-002	3
	Shunt D, 2.5 A	81667-003	3
	Shunt E, 5 A	81668-001	3
	Shunt F, 10 A	81668-002	3
	Shunt G, 20 A	81668-003	3
	Interconnecting Cable	83429	3
	Transportation Case	52524	1
J1	Terminal, Binding Post, Black	1803-017	3
J2	Terminal, Binding Post, Red	1803-018	3
J3 & J4	Connector, Coaxial, UHF	1703-006	3
S1	Switch Assembly	81630	3

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